APPENDIX-IV

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Outline of Proposed Research Work

1. **Name of the Scholar** **(In English)** **Sunil Rai Porwal**
   (In Hindi) सुनील राय पोरवाल
2. **Title of Research Work** **(In English)** **Studies on Phytoremedial Management of Effluent of Textile Industries.**
   (In Hindi) वस्त्र उद्योग अपशिष्ट के पादपोपचार प्रबंधन का अध्ययन।

3. Location

A. Institution / Department where the work to be done

Department of Botany,
M. L.V. Government College, Bhilwara.
Affiliated to M.D.S. University, Ajmer (Rajasthan)

B. Geographical Area of Investigation, if any

Phytoremedial potential of certain plant species will be tested at Laboratory of Plant Physiology and Biotechnology, Department of Botany, M.L.V. Government College, Bhilwara located in Bhilwara district of Rajasthan. Bhilwara district is situated between 25^0 00' to 25^0 3' north latitude and 74^0 10' to 75^0 28' east longitude. It is situated 100 m above the sea level. The total length of the district from west to east is 144 km while the breadth from north to south is 104 km approximately. Northern border of the district touches Ajmer district, northwest border touches district Rajasmand, south and southeast border touches district Chittorgarh and east and northeast border touches district Bundi and Tonk. The district appears rectangular in its general shape with one exception that its western side is hillocks jutting out here and there and undulating plains and hills in the south and north-east portion. The general slope of the district is from west to east (NIC, 2006).

4. Introduction, Importance of Proposed Investigation, Objectives

The moniker 'textile city' is apt for Bhilwara and it produces 75% of the country's textile demand. But there is a dark side to its sheen. The industry's poor effluent management system

has long poisoned the area's groundwater affecting agricultural lands and people's health. There are about 500 synthetic textile units in outskirts of Bhilwara on Chittorgarh, Gangapur and Mandal roads. Most units are engaged in spinning and weaving, apart from the 25 major textile processing units, which are the main water guzzlers. In 2004 SPHED (State Public Health Engineering Department) established that maximum open wells in rural sites in close proximity to the Kothari and Banas rivers. The industrial sites which are situated near these rivers had many harmful metals according to the rules of Bureau of Indian Standards (BIS). Above them lead is very harmful particularly deleterious to the brain and nervous system of small kids. The water also had high levels of chlorides making it hard. These chemicals were similar to those found in textile unit's waste.

Each unit has an effluent treatment plant but they had long been dumping untreated and partially treated effluents in drains that emptied in the nearby Kothari and Banas rivers. The RPCB (Rajasthan Pollution Control Board) had decided in 2005 that all industrial units must not release effluent without any treatment. However, these industries have been planting *Eucalyptus* trees in much area of agriculture land in its location. These units consume wastewater for irrigation. In early phase many industries drew water from tube wells, so it found extremely polluted and the areas' groundwater has became useless. High utilization of water and the high requirement for pure drinking water are major problems of textile industry.

Synthetic dyes are extensively used in many field of up to date technology, e.g. in various branches of the textile industry. A wide range of methods has been developed for the removal of synthetic dyes from waters and waste waters to decrease their impact on the environment. The technologies involve absorption on inorganic or organic matrices, decolorization by photocatalysis, and/or by oxidation processes, microbiological or enzymatic decomposition,

etc. (Mohana et al., 2007). But for all of these methods phytoremediation proves to be an efficient method.

Research and demonstrations are needed to develop more cost-effective technologies, appropriate for reclaiming such sites. Now a day's Bioremediation (the use of living organisms to control and destroy contaminants) is of increasing interest to minimize some of these problems. When green plants are used to remove heavy metals from the soil, bioremediation is known as 'Phytoremediation' (Marmiroli et al., 1999; Marmiroli and Monciardini, 1999; Varun et al., 2012).

The term phytoremediation (Phyto meaning plants and the latin suffix remediation meaning to clean or restore) actually means a plant-based technologies that is either naturally occurring or genetically engineered plants for cleaning contaminated environments. It is an aesthetically pleasing mechanism that can reuse remedial costs, restore habits and clean-up contamination in place rather than entombing it in place or transporting the problem to another site (Ensley, 1999; Glass, 2000; Zynda, 2001). Phytoremediation had been used to clean-up the radionuclide, pesticide (e.g. DDT and simazine), waste water from textile industries and heavy metals (Jagetiya et al., 2011; Giri, 2012; Mojiri et al., 2013).

In the present investigation, methods will be explored to remove contaminants through the "Green Technology" or phytoremediation. Present investigation/study will also be useful for developing certain affordable phytoremedial techniques to remediate effluent of textile industries.

Keeping the scenario in view, present investigation is undertaken to fulfill the following objectives:

1. The main objective of present study is to develop affordable protocols to remediate the affected areas of textile pollution through phytoremediation/bioremediation.

2. One more objective of present investigation is to know the physico-chemical characteristics of textile effluent.
3. Another objective of this investigation is to compare the phytoremedial potential of certain plant species.
4. One important objective of the study is to understand the physiology and biochemistry of selected plants species. This will be helpful in better programming of phytoremediation/bioremediation.

5. Review (Work Already Done on the Subject of Proposed Research Studies)

The current pattern of industrial activity alters the natural flow of materials and introduces novel chemicals into the environment. The rates at which effluents are discharged into the environment have been on the increase as a result of urbanization and industrialization. Human industrial, mining and military activities as well as farming and waste practices have contaminated large areas of developed countries with high concentrations of organic and inorganic pollutants. In addition to their negative effects on ecosystems and other natural resources, these sites pose a great danger to public health, because pollutants can enter food through agricultural products or leach into drinking water. Most of the effluents discharged from industries, contain toxic substances especially heavy metals. Heavy metals, such as Cd, Cu, Pb, Cr, Zn, and Ni are important environmental pollutants, particularly in areas with high anthropogenic pressure (USEPA, 2007). The presence of heavy metals in the environment is of major concern because of their toxicity, bio-accumulating tendency, threat to human life and the environment (Mojiri et al., 2013). Heavy metals are among the most conservative pollutants that are not subject to bacterial attack or other break down or degradation process and are permanent additions to the environment. As a result of this, their concentrations often exceed the permissible levels normally found in soil, water ways and sediments. Hence, they find their way up the food pyramid and can profoundly disrupt biological processes (Ibbini et

al., 2009). The heavy metal wastes and toxic substances which requires treatment process, usually dumped in the soil.

Methods are needed for removing heavy metals from contaminated soils (Phillips et al., 1995). Each of the conventional remediation technologies has specific benefits and limitations (Van der Lelie et al., 2001; Suzuki et al., 2002; Purohit, 2006; Ali et al., 2013) but these are either inadequate or too expensive and unsafe. Nowadays, bioremediation (the use of living organisms to control and destroy contaminants) is of increasing interest to minimize some of these problems. The use of microorganism to control and destroy contamination is of increasing interest to minimize some of these pollution problems called, "Bioremedaiton". Bacteria algae fungi and yeasts have all been found to absorb and breakdown metal compounds (Roane et al., 1996). When green plants are used to remove heavy metals from the soil, bioremediation is known as 'Phytoremediation' (Marmiroli et al., 1999; Marmiroli and Monciardini, 1999). Phytoremediation involves the use of green plants for *in situ* treatment of contaminated soils, sediments and water where plants degrade, assimilate, metabolize or detoxify inorganic or organic pollutants (Vidali, 2001).

It has advantages over other remediation practices that it is less expensive, less environmentally evasive, and easy to implement as well as offers aesthetic value. When decontamination strategies are impractical because of the size of the contaminated area, phytoremediation is advantageous. Due to the site honors, managers, their consultants and contractors, in applying this technology to private, superfund and brown field sites. Phytoremediation has many privileges over the traditional practices. First, in it the soil is treated in situ, which does not cause further destruction to the soil dynamics, secondly, plants are established, and they remain for consecutive harvests to continually remove the contaminants. In a single growing season, it is possible to grow and harvest multiple crops (Cai and Qin, 2006). The plants also provide the soil nutrients and stabilization by reducing

and wind water erosion. Thirdly, phytoremediation reduces the time workers are exposed to contaminated areas (Dushenkov et al., 1997).

On the basis of underlying process and applicability phytoremediation technology can be subdivided-

Phytoaccumulation, also called phytoextraction and refers to the uptake and translocation of metal contaminants in the soil by plant roots into the above ground portions of the plants. Certain plants called hyper-accumulators absorb unusually large amounts of metals in comparison to other plants. One or a combination of these plants have been allowed to grow for several weeks or months, they are harvested and either incinerated or composted to recycle the metals. This procedure may be repeated as necessary to bring soil contaminant levels down to allowable limits. If plants are incinerated, the ash must be disposed in a hazardous waste landfill, but the volume of ash will be less than 10% of the volume that would be created if they would be created if the contaminated soil itself were dug up for treatment (Jagetiya and Sharma, 2009; Jagetiya et al.,2011; Ali et al., 2013; Jagetiya et al., 2014).

Rhizofiltrartion is the adsorption or precipitation into plants roots or absorption of contaminants into the roots that are in solution surrounding the root zone the plants to be used for clean up are raised in green houses with their roots in water rather than in soil. To acclimatize the plants once a large root system has been developed, contaminated water is collected from a waste site and brought to the plants where it is substituted for their water source. The plants are then planted in the contaminated area where the roots take up the water and the contaminants along with it. As they become saturated with contaminants, they are harvested and either incinerated or composted to recycle the contaminants (Ali et al., 2013; Jagetiya et al., 2014).

Phytostabilization is the use of certain plant species to immobilize contaminants in the soil and ground water through absorption and accumulation by roots, adsorption on to roots, or precipitation within the root zone (Das et al., 2005). This process reduces the mobility of the contaminant and prevents migration to the ground water or air and it reduces bioavailability for entry into the food chain. This technique can be used to re-establish a vegetative cover at sites where natural vegetation is lacking due to high metal concentration in surface soils or physical disturbances to surface materials. Metal tolerant species can be used to restore vegetation to the sites, thereby decreasing the potential migration of contamination through wind erosion, transport of exposed surface soils, leaching of soil and contamination of ground water (Jagetiya et al., 2011; Jagetiya et al., 2014).

Phytodegradation also called phytotransformation, is the breakdown of contaminants taken up by plants through metabolic processes within the plant, or the breakdown of contaminants external the plant through the effect of compounds (such as enzymes) produced by plants. Pollutants are degraded, incorporated into the plant tissues, and used as nutrients. Rhizodegradation is also called enhanced rhizosphere biodegradation (Das et al., 2005). Phytostimulation, or plant-assisted bioremediation/degradation is the breakdown of contaminants in the soil through microbial activity that is enhanced by the presence of the rhizosphere and is a much slower process then phytodegradation. Microorganisms (yeast, fungi, or bacteria) consume and digest organic substances for nutrition and energy. Certain microorganisms can digest organic substance such as or solvents that are hazardous to human and breakdown them into harmless products through biodegradation. Natural substances by the plant roots- sugars, alcohols and acids- contain organic carbon that provides food for soil microorganisms and the additional nutrients enhance their activity. Certain microorganisms can facilitate the oxidation of Fe^{+2} to Fe^{+3}. The Fe^{+3} ions, in turn, can convert insoluble

uranium dioxide to soluble UO_2. This reaction enhances the mobility of uranium in soil from mining and milling wastes (Jagetiya et al., 2014).

Phytovolatilization is the uptake and transpiration of a contaminant by a plant, with release of the contaminant or a modified form of the contaminant to the atmosphere from the plant. Phytovolatilization occurs as growing trees and other plants takes up water and the organic contaminants. Some of these contaminants can pass through the plants to the leaves and volatilize into the atmosphere at comparatively low concentrations (Jagetiya and Sharma, 2009). Rapid technological advances, speedy growth in urban sector and unplanned human settlement in the cities, have resulted in the pollution problem. The kind of water, which emerges out after use from industries is termed as industrial effluent. Effluent from different industries has different kind of characteristics. The quality of waste water from textile operation is given in terms of pH, BOD, alkalinity solid matters, metals etc.

Effluent form textile industry of Bhilwara contains coloring matters, acidic effluents, suspended solids, waxes, unreached dyes, starch products, heavy metals etc., which are releasing different stage of processing. These effluents have high BOD, pH, and temperature. They have bad odor due to dyeing operation and is alkaline in nature. These industrial effluents constitute a major source of metallic pollution of the hydrosphere. Sharma et al. (1999); Patel and Shrivatava (1999); Sharma et al. (2001); Hussain et al. (2001) concluded that the ground water of an industrial area and its surrounding have poor quality due to impact of the industrial waste water discharged on land.

A study was carried out in order to access the impact of the various pollutants of textile dyeing effluent on the surface water quality of the industrial area inside Dhaka-Nayaranganj-Demra (D.N.D.) Embankment, Narayanganj by Sultana et al. (2009). The result showed that textile dyeing industries inside D.N.D. Embankment area discharge effluents composed of various physico-chemical and anionic pollutants at considerably higher lever composed to

pollution limit. Further, the surface water around the textile dyeing industries also contains various physico-chemical and anionic pollutants at intolerable limit. A significant correlation was also observed among some important water parameters of the effluents and surface water. The above findings pointed out that the surface water around the study sites is highly polluted and not good for human consumption.

Moren et al. (2009), studies on effects of sewage treatment on textile effluent. Textile effluent is discharged to sewer with little or no destructive treatment. Using three separate sample of effluent the initial toxicity was tested using the aquatic invertebrate *Daphnia magna*. Result showed relatively good biodegradability but negligible toxicity reduction.

Sidi and Tank (2014) studied on *Eichhornia crassipes* as a potential bioremediating agent in treating the untreated effluent and treated effluent being released into Kadodara khadi, Surat they found COD reduction up to 81% and PO_4 up to 72.50% on an average.

Muthunarayanan et al. (2011) mentioned experiments on water Hyacinth (*Eichhornia crassipus*) and proved the efficiency of this plant to remove the color and degrade the dye by about 95% with red RB and 99.5% black B.

Gupta et al. (2012) studied on treatment of waste water by using different plants species like water hyacinath (*Eichhornia crassipus*) water lettuce (*Pistia stratiotes*) and vetiver grass and concluded that floating plant system is predominant method which is economic require little maintenance and increase the biodiversity he found that treatment capability of different plant species depends on different factors like climate contaminants of different concentration temperature etc. physico-chemical properties varies plant to plant. Kumar et al. (2012) studied on treatment of paper industry effluent by using water hyacinth (*Eichhornia crassipus*) have strong reproduction potential and using this plant for phytoremediation.

Sukumaran et al. (2012) used titanium dioxide producing factory and an ilmanite separating factory effluents for phytoremediation purpose. For this purpose he used marshy green plants

Typha, Azola and Lemna and done the experiment on physico-chemical characteristics and he finally concluded that constructed wetlands may be an economic option for secondary treatment of stabilization pond effluent, the most common treatment system in use in economically poor treatment system in use in economically poor countries.

Davies et al. (2005), experimented that in constructed wetland containing vertical flow intermittent feeding *Phragmites australis* is used to eliminate azo dye from textile effluents. To demonstrate the role of *Phragmites australis* peroxidases (POD) activity in deficient condition in a vertical flow constructed wetland (VFCW), acid orange 7 (an azo dye) was applied. Acid orange 7 is degraded by crude plant extract and its aromatic amines, after 120 hours in content with hydrogen peroxide and removals of 3.2 – 5.7 mg acid orange 7 g^{-1} *P. australis* were obtained for 40 mg acid orange $7g^{-1}$, 8 mg acid orange $7g^{-1}$ *P. australis*. To eliminate azo dye from effluent the VFCW was found better.

Ibbini et al. (2009) studied on phytoremediation in textile dyes. Tests were established with 20-40 mg l^{-1} dye solutions of various colors. 15 days old sunflower seeding were laid into known volume dye solution were used in the test. Evan's Blue dye is found the most favorable decolorized azo dye among the many dyes tested.

To eliminate Brilliant Blue G (BBG) dye which is a sample of dye mixture and a real textile waste, both wild and tissue-cultured plantlets of *Petunia grandiflora* is examined and determined its Phytoremedial strength (Anuprita et al. 2012). By seed culture method scientist found *in vitro* cultures of *P. grandiflora*. Natural as well as tissue-cultured plantlets were applied independently. The enzymatic study was carried prior and later removal testing of BBG dye. By dye degradation process many metabolites were formed which were further studied by high-performance liquid chromatography, Fourier transform infrared spectroscopy, gas chromatography–mass spectrometry, UV–vis spectroscopy, and phytotoxic analysis. Unique fetchers of dye mixture and wastewater were also analyzed. The resultant

removal of BBG dye more than 80% was shown by the natural and tissue cultured plantlets of *P. grandiflora*. In plant roots remarkable enhancement was noticed in the It was found that enzymatic activities of NADH-2, laccase, 6-dichlorophenol-indophenol reductase, lignin peroxides and tyrosinase in the roots of the plants. *P.grandiflora* is also capable to remove the mixture of synthetic dyes and textile wastes. The non-hazardous characters of metabolites are exposed by Phytotoxicity test. To remove the color and degrade BBG to harmless metabolites is exhibited by *P. grandiflora* excellently. Thus efficiency of plant has proved to remove a mixture of textile waste and synthetic dye.

Mondal (2008), studied on various techniques of dye elimination from dye house sewage. Toxic wastes released from dye houses effects the aquatic surroundings adversely. In the textile effluent dye is the most difficult part to treat because it has a strong complex chemical structure. In this study he explained various techniques like degradation of color by anaerobic reaction, adsorption of dye by silica, biomaterials, activated carbon and functional polymer granules for effluent treatment.

Ertugrul et al. (2008), studied on treatment of dye waste water by an immobilized thermophilic cynobacterial strain: *Phormidium* sp. In investigation performed at pH 8.5 with different initial dye concentration between 9.1 mg/1 and 82.1 mg/1 and at 450 °C, calcium alginate immobilized *Phormidium* sp. showed high dye decolorization, with maximum uptake yields ranging from 50% to 88% at all dye concentrations tested. The highest color removal was detected at 450 °C and 500 °C incubation temperatures for all dye concentration. As the temperature decreased, the removal yield of immobilized *Phormidium* sp. also decreased.

Mangkoedihardjo et al. (2008) reported an assessment of hexavalent Cr removal from soil with and without compost amendment by *Pterocarpus indicus* and *Jatropha curcas*. Green house experiment was conducted and consisted of range finding test and definitive test for various concentrations of hexavalent chromium. Result of range finding test showed that both

plants were able to remediate hexavalent Cr polluted soil of less than 90 mg Kg^{-1}. The removal half time (t-50) of *Jatropha* was about twice shorter than *Pterocarpus*.

Kanrimi (2013) studied the potential of alfalfa and sorghum for phytoremediation of soil contaminated Cr. In his experiment of phytoremediation he find that concentration of Cr in soil was decreased 60-74% by alfalfa and 51.2-69.5% decreased by sorghum this shows that alfalfa and sorghum are effective accumulator plants for phytoremediation on Cr. He also concluded that potential of alfalfa was more than sorghum for phytoremediation of Cr polluted soil.

Giri (2012) developed the phytoremediation potential of the aquatic plant *Eichhornia crassipus* for As (III) and Cr (VI) from water. The accumulation, relative growth and bio-concentration factor of plant on treatment with different concentrations of As(III) and Cr(VI) solution significantly increased ($P<0.05$) with the passage of time. Plants treated with 0.100 mg l^{-1} As (III) accumulated the highest concentration of As in roots (7.20 mg kg-1, dry weight) and shoots (32.1 mg kg-1, dry weight); while those treated with 4.0 mg l^{-1} of Cr (VI) accumulated the highest concentration of hexavalent Cr in roots (1320 mg kg-1, dry weight) and shoots (260 mg kg-1, dry weight) after 15 days. The plant biomass was characterized by SEM, EDX, FTIR and XRD techniques. He investigated Microwave-assisted extraction efficiency for extraction of arsenic from plant materials by comparison of the results by three extracting solutions: (i) 10% (v/v) tetra methyl ammonium hydroxide (TMAH) (ii) deionized water and (iii) modified protein extracting solution at different temperature and times. Extraction of Cr ions was carried by same procedure from plant materials using three extract solutions: (i) 0.02 M ethylene di amine tetra acetic acid (EDTA), (ii) deionized water and (iii) HCl solution at different temperature and times. Chromatograms are obtained for As and Cr species in plant shoot biomass by using HPLC-ICP-MS.

Mathur et al. (2004) experimented on mutagenicity evaluation of textile effluents or dye releasing units of Sanganer, Jaipur (India). In Jaipur district Sanganer town, A well known dyeing and printing industries which are located at Sanganer in Jaipur district(Rajasthan, India). Almost 400 industries related to textile printing processes, which release textile waste and dyes into nearby aqueous environment without any management. This toxic textile wastewater is the reason of environmental pollution and also disturbs the structure of flora, fauna, and the general health of people adversely.

To examine the toxicity of azo and anthraquinone dyes, Novotny et al. (2006), experimented on comparative use of bacterial, protozoan and algal tests. Toxicity of two azo dyes [Reactive Orange 16(RO16); Congo Red (CR)] and two anthraquinone dyes [Remazol Brilliant Blue R (RBBR); Disperse Blue 3 (DB3) were compared using bacterium *Vibrio fischeri*, microalgae *Selenastrum capricornutum* and ciliate *Tetrahymena pyrifomis*. The following respective endpoints were involved: acute toxicity measured as bacterial luminescence inhibition, algal growth inhibition, and the effect on the protozoa including viability, growth inhibition, grazing effect and morphometric effects. In addition, mutagenicity of the dyes was determined using Ames test with bacterium *Salmonella typhimurium*. DB3 dye was the most toxic of all dyes in the bacterial, algal and protozoan tests.

Serfor-Armah et al. (2004), studied on Rhodophyta seaweed species as bioindicators for monitoring toxic element pollutants in the marine ecosystem of Ghana. Six seaweed species of the Rhodophyta family were sampled for a two year period from June 1996 to August 1998 along the Atlantic cost of Ghana (part of the Atlantic Ocean). The species were analyzed to determine the levels of eleven chemical elements namely: Al, As, Br, Cd, Fe, La, Mn, Ni, Hg, V, and Zn by Instrumental Neutron Activation Analysis (INAA). Al, Br, Ni, and Zn were measured in all the seaweed species studied. Precision and accuracy of the method

have been evaluated and the detection limits also calculated. The results showed high variability in and between species, among sampling sites and times of collection.

Kulkarni et al. (2006) carried out an investigation phytoremedaition of textile process effluent by water hyacinth in the KITS College of Engineering Campus, for studying reduction of COD and metals from textile process effluents. It has been observed that there is a reduction of 80% in COD and about 25-45% reduction in metals after 18 days period.

Harrelkas et al. (2008) studied on photocatalytic and combined anaerobic-photocatalytic treatment of textile dyes. To removal of recalcitrant dye residues which are an autoxidized chemically reduced azo dyes after biological sequential anaerobic-aerobic management, the above method was used. 90% color removal is possible from crude as well as autoxidized chemically reduced dye solutions from Photocatalysis procedure. Almost value of 50% UV – absorbance and COD were also eliminated. The final result of phtocatalytic treatment was not toxic toward methanogenic bacteria.

Pourbabaee et al. (2006) experimented with a new isolate of *Bacillus* sp. to remove the color and toxic effect of a disperse dye in textile wastewater. Many capable aerobic species were isolated for removal of dyes in a textile mill effluent. According to FT-IR and GC-MS data the initial components which were present in the untreated wastewater, depart after 20 days of treatment, means confirming breakdown of the dye. Unprocessed wastewater samples undergoes phytotoxic tests using the seed of *Lens orientalis, Triticum aestivum* and *Triticum boeoticum* which shows that the *Lens orientalis* is the most sensitive while the *Triticum boeoticum* is the most resistant. In another situation the treated wastewater allows 90% germination in *Triticum boeoticum* seeds and 100% germination in *Lens orientalis* and *Triticum aestivum.*

Ramachandran et al. (2013) studied on biological elimination of color of dye effluent. Researchers proved that many microorganisms and plants varieties are efficient to remove the

color of extensive range of cationic and anionic dyes. For this purpose they used various parameters like PH, temp, and dye bacteria through biodegradation and biosorption mechanism performance.

Mahajan and Kaushal (2013) investigated *Chara vulgaris* as a viable biomaterial for biological treatment of congo red in aqueous solution. He examined the biological decolorization efficiency with help of UV- vis and Ft –IR spectroscopy and effect of various parameters like reaction time, pH, initial dye concentration, temperature, amount of algae etc.

Aken et al. (2010) experimented on management of polychlorinated biphenyls (PCBs) waste containing soil and water by using transgenic plants and associated bacteria plants can help mitigate environment pollution by PCBs through phytoextraction, phytotransformation, rhizoremedation. Though PCBs are gradually taken up and degraded by plants and associated bacteria due to by hydrophobicity and chemical stability. To overcome this problem biphenyle deoxygenase have been introduced into higher plants and bacteria have also genetically modified which is the best proficient appliance of phytoremediation for the removal of PCBs dye.

Mojiri et al. (2013) investigated the phytoremedial potential of southern cattail (*Typha domingensis*) for removal of heavy metals from municipal waste. He used central composite design (CCD) and response surface methodology (RSM). The quantity of removed Cd, Pd, Ni were found 0.3692, 0.9725, 0.4681 mg kg^{-1} in most favorable condition and translocation factor (TF) in 24,48,72 h experiment were noted 1, 1.07, 1.0, 1.11, 1.32, 1.00, 1.5, 1.20 and 1.02 for each heavy metal (Pd, Ni, Cd), respectively. Above tests proved that *Typha domingensis* have a strong potential for phytoremediation of these heavy metals from wastewater.

Hasanuzzaman et al. (2013) stated that plant growth and development involve numerous biochemical reactions that are sensitive to temperature. Plant responses to high temperature

(HT) vary with the degree and duration of HT and the plant type. They reported that plants possess a number of adaptive, avoidance, or acclimation mechanisms to cope with HT situations. In addition, major tolerance mechanisms that employ ion transporters, proteins, osmoprotectants, antioxidants, and other factors involved in signaling cascades and transcriptional control are activated to offset stress-induced biochemical and physiological alterations. Plant survival under HT stress depends on the ability to perceive the HT stimulus, generate and transmit the signal and initiate appropriate physiological and biochemical changes. HT-induced gene expression and metabolite synthesis also substantially improve tolerance. The physiological and biochemical responses to heat stress are active research areas, and the molecular approaches are being adopted for developing HT tolerance in plants. This article reviews the recent findings on responses, adaptation, and tolerance to HT at the cellular, organelles, and whole plant levels and describes various approaches being taken to enhance thermo tolerance in plants.

Mikhalovsky et al. (2000) suggested as an efficient method for soil decontamination from radionuclides (Zhu and Shaw, 2000), whereas sorbents have been widely used for water treatment. He studied a series of inorganic ion exchangers, EDTA, natural and synthetic mineral adsorbents, activated carbons and adsorbent composites together with plants on the land contaminated with radio nuclides in the Chernobyl zone (Polesye and Chernobyl districts). The selection of adsorbents was based on their ability to remove radio Cs from tap water, with Kd at least 1,000. Amount of adsorbent placed into the root zone of the plants was 50-150 gm^{-1}. The plants chosen for the study are known for their ability to accumulate heavy metals. Soil activity, mainly due to ^{137}Cs, was 1-20 kBq kg^{-1}. Migration of radio nuclides was studied by measuring radioactivity of soil, adsorbents and plant biomass. In the presence of ion exchangers and EDTA that strongly bind metal ions plants accumulated fewer radio activities than in the adsorbent-free soil. However, it was found that, against our

original expectations, addition of certain adsorbents (activated carbon and natural minerals) to the soil accelerated and increased 2-4 fold the amount of radioactivity accumulated in corn, rape, sunflower, lupine and potatoes.

For dye removal from textile effluent Kant (2012) used activated carbon. He experimented on two different samples of Granular Activated Carbon in Continuous Flow Process and Static Batch Method by adsorption of various acidic, reactive and direct dyes. Optical density of blank solution of different concentration varies from 10 mg l^{-1} to 100 mg l^{-1} and optical densities of solutions after adsorption on activated carbon sample were recorded for study.

Kamaruddin et al. (2013) synthesized a new composite adsorbent from coconut shell activated carbon (CSAC) and clinoptilolite (CL) for the removal of color and heavy metals from real textile waste water. OPC as the binder agent held the advantages of CSAC and CL which improved the adsorption capacities of color and Pb. He proved that the prepared composite adsorbent with interfacial pores show better mass transfer activity by its mechanical properties and stability. The surface area of the CSAC/CL composite adsorbent was observed at 39.32 m^2 g^{-1} having pore diameter of 3.38 nm which in the mesoporous class. The equilibrium data was best fitted to Langmuir. Meanwhile, the kinetics model of pseudo-second-order was favorable with high correlation coefficient more than 0.98 for both color and Pb adsorption. The characterization of the CSAC/CL composite adsorbent indicates that the presence of SiO_2 (clinoptilolite) in the mixtures influenced the adsorption properties and chemical functional group whereas OPC played a significant role in strength development of the adsorbent.

Mubeen et al. (2010) concluded that adsorbent prepared from *Calotropis procera* roots can be used for treatment of heavy metals in waste water he treatment of heavy metals in waste water. He treated the Cu(II) containing waste water with biomass prepared from roots of *Calotropis procera*. These studies were carried out in order to determine some operational

parameters of Cu (II) sorption such as the time required for the metal-biosorbent equilibrium the effect of change in biomass quantity and effect of contact time on percentage removal of Cu.

In a batch reactor, Lata et al. (2006) prepared adsorbents from *Parthenium hysterophorus* an unwanted weed which is utilized to eliminate methylene blue dye from textile wastewater. The adsorbents are sulphuric acid treated *Parthenium* (SWC) and phosphoric acid treated *Parthenium* (PWC). Aqueous solutions of various concentrations (50-250 mg l^{-1}) were shaken with certain amount of adsorbent to determine the adsorption capacity on SWC and PWC for methylene blue. He examined the impact of initial pH, adsorbent surface change, adsorbent dose, initial dye concentration and contact time on dye elimination process. For comparative study ditto investigation were done with commercially available activated carbon (AC). Initial pH of aqueous solution had negligible effect on the adsorption capacity of all the studied adsorbents. Maximum dye was sequestered from the solution within 60-90 min after the beginning of every experiment. At 500 mg l^{-1} methylene blue concentration, AC had 1.93 and 3.4 times more adsorption capacity than PWC and SWC, respectively. The adsorption capacity of the studied adsorbents was in the order AC > PWC > SWC. Adsorption follows both Langmuir and Freundlich isotherm models. The results showed that SWC and PWC can be considered as potential adsorbents for methylene blue removal from dilute aqueous solutions.

Romeh (2014) tested *Plantago major* to clean water polluted with cynophos insecticide. He concluded that biosorption capacity (KF) of cyanophos were 76.91, 26.18 and 21.09 ug g^{-1} for dry root, fruit and leaves of the *Plantago major* respectively viable *Plantago major* in water significantly reduced cyanophos by 11.0% and 94.7% during 2 h and 9 d of exposure as compared with 0.8% , 36.9% in water without the plantain. In water with plantain, cynophos significantly accumulated in plantain roots and leaches to reach maximum levels after two

and four hours of treatment, respectively. Cynophose residue in water removed efficiently by *Plantego major*.

Rao et al. (2010) stated that enzymes have a great potentiality to effectively transform and detoxify polluting substances because they have been recognized to be able to transform pollutants at a detectable rate and are potentially suitable to restore polluted environments. He examined some classes of pollutants and enzymes capable of transforming them effectively in to innocuous products. Particular attention will be devoted to pollutants with a high polluting potential such as polyphenols, nitrates, PAHs, cyanides and heavy metals. The enzymatic processes developed and implemented in some of these detoxification treatments.

Mugdha and Usha (2010) studied on enzymatic treatment of waste water containing dye stuff using different delivery system and evaluate different methods in which enzymes can be delivered to target effluents like use of microbial cells plant tissues entire plants enzyme delivery as cell free enzyme extracts immobilized form or in the form of different nanoparticles. He concluded that enzymes are versatile and efficient remediating tool which have immense catalytic potential in waste water treatment.

Ali et al. (2008), studied on bioremediation perspective of textile effluent and physico-chemical characterization, dyes and bacteriological condition of effluent released from textile unit demonstrated significantly high value of temperature (400), EC (3.57 us^{-1} m), TSS (5496 mg 1^{-1}), pH (9.5), COD (1632 mg 1^{-1}), TDS (252 mg 1^{-1}), BOD (548 $mg1^{-1}$), Heavy metal ions (0.28-6.36 mg 1^{-1}) and color above the prescribed fresh water limits.

To remove malachite green dye from textile wastewater by neem sawdust adsorbate an experiment is done by Khattri and Singh (2009). To evaluate the potential of neem sawdust for malachite green dye elimination from waste water the studies were carried out under many experimental conditions such as pH, temperature, agitation time, adsorption dose and dye concentration. Equilibrium isotherms were analyzed by the Lang muir models of

adsorption and were applicable with maximum monolayer adsorption capacity of 4.354 mg/ g. Anaerobic treatability of areal cotton textile waste water was investigated in a fluidized bed reactor (FBR) with pumice as the support material. They indicated that anaerobic treatment of textile waste water studied was possible with the supplementation of an external carbon force in the form of glucose (about 2 g l^{-1}) (Sen and Demirer, 2003).

Nigam et al. (2004) studied on decolorization of effluents form the textile mill by a microbial consortium. Under anaerobic conditions a microbial consortium, PDW, was used and found excellent to eliminate color from textile effluent dyes. During utilization of inexpensive and easily available carbon sources like starch, lactose and distillery waste, PDW was found efficient dye removal consortium.

Mohana et al. (2007) demonstrated a novel bacterial consortium to eliminate the textile dye Direct Black 22 using response surface methodology for optimization of medium. Response surface methodology (RSM) having a central composite design (CCD) in four features was applied for dye removal method. For removal of color of various azo dyes bacterial consortium was found capable. These four various predictions through above technique was certified by confirmatory experiment and thus this bacterial consortium is used for effluent treatment.

Noreen et al. (2014) reported that biological treatment of textiles has become a preferred choice over chemical treatment because of it being less harmful to textiles and environment. Bio-polishing refers to the treatment of cellulose-containing textile fabrics with cellulose enzyme for removing protruding fibers in order to achieve a smooth and polished surface. They produced a cellulase enzyme from *Aspergillus niger* and find out optimum conditions for its application in bio-polishing of polyester/cotton blended fabric. It was observed that the produced cellulases exhibit optimum activity at pH 5.0 and 55 °C temperature. The enzyme

activity/concentration may be varied during bio-polishing for achieving the desired degree of bio-polishing on polyester/cotton blended fabrics.

6. Research Gaps Identified in the Proposed Field of Investigation (Based on the review)

Due to use of abundant amount of chemical and dyes, effluent is produced in large quantity at many stages of textile process units. These toxic waste residues released into the surroundings which ultimately affect adversely one or more species in the environment with consequential modification in the environmental equilibrium (Asamudo et al., 2005).

There are limited numbers of reports on physico-chemical charactestics of textile effluent particularly for Bhilwara city. Further, there is rare studies phytoremediation perspective of textile effluents. Traditional methods for the cleanup of pollutants usually involve the removal of unwanted materials through sedimentation and filtration and subsequent chemical treatment such as flocculation, neutralization and electro-dialysis before disposals. These process are not sufficient for treatment of effluent more ever, they are often laborious and expensive. Phytoremediation using some specific plant species is to be studied and specific techniques are needed to remediate effluents of industries of Bhilwara city. The present investigation will be useful for fulfilling the existing gaps in this field of research.

7. Major Hypothesis, If any:

The present investigation is based on following hypotheses-

1. Large number of dyes reagents and chemical are being used in textile processing units. Therefore, it is hypothesized that the discharge of textile industries has specific/unique physico-chemical characteristics.
2. All the species in the nature do not have equal absorption and accumulation/degradation of pollutants. Only few species are capable of maximum absorption and accumulation/ degradation of pollutants. On the basis of this fact, certain species will be tested for phytoremedial potential.

3. Treated Plant parts or stuffs may be used as adsorbent many times. Plant growing around polluted sites will be selected and prepared as adsorbent. It is expected that prepared adsorbent have differential dye removal potential.
4. Phytoremediation/bioremedial perspective of textile effluent varies from different treatment capabilities of adsorbents or filter beds. This is hypothesized on the basis of this fact we can maximize the capacity of existing phytoremediation/bioremediation technologies by altering ingredients or their concentrations.

8. Research Methodology:

A. Methodology

1. Climatic data collection: Climatic details will be collected from various Departments of Universities, Dry Land Farming Research Station, Arjia (Bhilwara), Meteorology Department, Bhilwara and various other agencies.
2. Variation in physico-chemical properties of textile effluent such as pH, conductivity, turbidity, alkalinity, DO, free CO_2, BOD, TDS, chlorides, phosphates etc. will be recorded (APHA, 1989 and Trivedi and Goel, 1986). For this textile effluent will be collected in plastic bottles in the vicinity of industrial sites and will be analyzed for physico-chemical properties on return back to laboratory.
3. Phytoremedial efficiency of certain plant species (*Brassica campestris, Helianthus annuus, Hyptis suaveolens Phragmites australis, Parthenium hysterophorus* etc.) will be tested. Test plants will be grown in specially designed pots and treated with various concentrations of textile effluent diluted with tap water. Species with better phytoremedial potential will be screened on the basis of tolerance, biomass production and accumulation of pollutants.
4. Physiology (growth parameters) and biochemistry (chlorophyll contents, protein contents, proline contents and SOD activity) of better screened plant species will be studied.

5. Certain affordable protocol will be developed to remediate the textile effluent. Various adsorbents will be prepared from parts of plant species growing around textile industrial sites and these adsorbents will be tested for removal of dyes from textile discharge. These adsorbents will be treated further with different reagents to enhance their dye removal potential.

B. Chapter wise details

Chapter-1	INTRODUCTION	An introduction to the subject of work will be reported in this chapter.
Chapter-2	STUDY SITES	Climatic details of study sites will be given in the chapter. Data will be collected from various agencies.
Chapter-3	EFFLUENT CHEMISTRY	Physico-chemical characteristics of textile effluent from selected sites will be reported in the chapter.
Chapter-4	SCREENING STUDY	The plant species with best phytoremedial potential will be screened and selected.
Chapter-5	PHYSIOLOGICAL AND BIOCHEMICAL STUDIES	Physiology and biochemistry of better screened species will be discussed in this chapter.
Chapter-6	PHYTOREMEDIAL MANAGEMENT	Certain affordable techniques/ protocols will be developed for remediation of effluent of textile industries. Data and methods will be reported in this chapter.

9. List of Reference Cited

Aken, B.V., Correa, P.A. and Schnoor, J.L. 2010. Phytoremediation of polychlorinated Biphenyls: New trends and promises. Environ. Sci. Technol. 44: 2767-2776.

Ali, H., Khan, E., Sajad, M. A. 2009. Phytoremediation of heavy metals- concepts and applications. Chemosphere. 91:869-881.

Ali, M., Hameed, A. and Ahmed, S. 2009. Physicochemical characterization and bioremediation perspective metals by indigenous bacteria. J. Hazard. Mater.164: 322-328.

APHA, 1989. Standard methods for the examination of water and waste water. 17th ED. New York.

Asmudo, N.U., Daba, S. and Ezeronye, O.U. 2005. Bioremediation of textile effluent using phanerochaete chrysosporium. Afr. J. Biotechnol. 4: 1548-1553.

Cai, Z.C. and Qin, S.W. 2006. Dynamics of crop yields and soil organic carbon in a long-term fertilization experiment in the Huang-Huai-Hai Plain of China. J. Agri. Sci. 4: 2012.

Cole, A.G. 1979. Text Book of limnology. 2nd Ed. The C.V. Mosby Company. St. louis, Toranto, pp. 426.

Das, I., Gosh, K. and Sanyal, S.K. 2005. Phytoremediation: A potential option to mitigate arsenic contamination in soil water plant system. Everyman`s Sci. 2: 115-123.

Davies, L.C., Carias, C.C., Novais, J.M. and Dias, S.M. 2005. Phytoremediation of textile effluents containing azo dye by using *Phragmites austrails* in a vertical flow intermitted feeding constructed wet land. Ecol.Eng. 25: 594-605.

Dushenkov, S., Kapulink, Y., Blaylock, M., Sorochisky, B., Raskin, I. and Ensley, B. 1997. Phytoremediation: A novel approach to an old problem. In: Global Enviornmental Biotechnology (D. L. Elsevier Sciences and B.V. Netherlands Eds). pp. 563-572.

Ensley, B.D., Blaylock, M.J., Dushenkov, S., Kumar, P.B.A.N and Kapulnik, Y. 1999. Inducing hyperaccumulation of metals in plant shoots. U.S. Patent 5917117.

Ertgrul, S., Bakir, M. and Donmez, G. 2008. Treatment of dye-rich waste water by an immobilized thermophilic cyanobacterial strain: *Phormidum* sp. Ecol. Eng.2: 244-248.

Ezeronye, O.U. and Okerentugba, P.O. 1999. Performance and efficiency of a yeast biofilter for the treatment of a nitrogen fertilizer plant effluent. Int. J. Microbial. Biotechnol. 15: 515-516.

Giri, A.K. 2012. Removal of arsenic (III) and chromium (VI) from the water using phytoremediation and bioremediation techniques department of chemistry national institute of technology. Department of chemistry, National institute of technology Rourkela - 769 008. Ph.D. Thesis.

Glass, D.J. 2000. Economic potential of phytoremediation. In: Phytoremedition of toxic metals (Raskin, I. and Ensley, B.D. Eds.). John Wiley and Sons. New York.pp 15-31.

Gupta, P., Roy, S., Mahindrakar, A.B. 2012. Treatment of water using water hyacinth, Water lettuce and vetiver grass-A Review. Resour. Environ. 2: 202-215.

Hasanuzzaman, M., Nahar, K., Alam, M.M., Roychowdhury, R. and Fujita, M. 2013. Physiological, biochemical, and molecular mechanisms of heat stress tolerance in plants. Int. J. Mol. Sci. 14: 9643-9684.

Herrelakas, F., Paulo, A., Alves, M.M., Khadir, L.E., Zahraa, O., Pons, M.N. and Vanderzee, F.P. 2008. Photocatalytic and combined anaerobic photocatalytic treatment of textile dyes. Chemosphere. 72: 1116-1822.

Hussain, J., Sharma, K.C., Hussain, I., Ojha, K.G. and Vaidya, V.K. 2001. Physico-chemical characteristics of water for bore wells of an industrial town Bhilwara, Rajasthan: A correlation Study. Asian. J. Chem. 126: 509-512.

Ibbini, J.H., Davis, L.C., Erickson, L.E. 2009. Phytoremediation in Education: Textile Dye Teaching Experiments. Int J. Phytoremediat. 11: 451-462.

Jagetia, B. L. and Sharma, A. 2009. Phytoremediation of radioactive pollution: present status and future. Indian J. Bot. Res. 5: 45-78.

Jagetiya, B. L., Sharma, A., Soni A., and Khatik U. K. 2014. Phytoremediation of radionuclides: A report on the state of the art. In: Radionuclide Contamination and Remediation Through Plants. (Gupta D. K. and Walther C. Eds.), pp 1-31. Springer International Publishing Switzerland.

Jagetiya, B.L., Soni, A., Kothari, S. and Khatik, U. 2011. Bioremediation: An ecological solution to textile effluents. Asian J. Bio. Sci. 6: 248-257.

Kamaruddin, M.A., Yusoff, M.S., Aziz, H.A., Ismail, M.N. 2013. Preparation and characterization of composite embedded clinoptilolite for the removal of color and Lead from textile waste water. International J. Sci. Invent. 1: 37-47.

Kant, R. 2012. Textile dyeing industry. Environ. Hazard. J. 4: 22-26.

Karimi, N. 2013 comparative Phytoremediation of chromium- contaminated soil by alfalfa (*Medicago Sativa*) and *Sorghum bicolor* (L) monech. Int. J. Environ. Sci. 1: 44-49.

Karthikeyan, J. and Venkata Mohan, S. 1999. Advances in industrial pollution control, 1st ed. Techno Science Publications. pp. 250-251.

Khattri, S.D. and Singh, M.K. 2009. Removal of malachite green from dye waste water using neem sawdust by adsorption. J. Hazard. Mater. 167:1089-1094.

Kulkarni, B.V., Ranade, S.V. and Wasif, A.L. 2008. Phytoremediation of textile process effluent by using water Hyacinth-A polishing treatment. Int. J. Environ. Manag. Technol. 5: 18-27.

Kumar, P.S., Kumar, S.S., Anuradha, K., Sudha, B. and Shahbai, A. 2012. Phytoremediation as an alternative for treatment of paper industry effluents by using water Hyacinth (*Eichhornia crassipus*)-A polishing treatment. Int. J. Chem. Environ. 2: 95-99.

Lata, H., Garg, V.K. and Gupta, R.K. 2006. Removal of a basic dye from aqueous solution by adsorption using *Parthenium hysterophorus*: An agricultural waste. Dyes Pigments. 74: 653-658.

Mahajan, P. and Kaushal, J. 2013. Degradation of congo Red Dye in aqueous solution by using phytoremediation potential of *Chara vulgaris*. Chitkara Chem. Rev. 1: 67-75.

Mangkoedihardjo, S., Ratanawati, R. and Alfinti N. 2008. Phytoremediation of hexavalent chromium polluted soil using *Pterocarpus indicus* and *Jatropha curcas* L. Environ. Eng. J. 4: 338-342.

Marmiroli, N. and Monciardini, P. 1999. Phytonet, a thematic network devoted to scientific, economical, environmental and social aspects. Int. J. Phytoremediat. 1: 125-138.

Marmoli, N., Marmoli, M. and Monciardini, P. 1999. Phytoremediation: How plants can help in cleaning the environment. In: Perspectives in Ecology, (Farina, A., Ed.). Backhuys Publishers, Leiden, the Netherlands.pp 491-496.

Mathur, N. Bhatnagar, P. Nagar, P. and Bijarnia, M.K. 2004. Mutagenicity assessment of effulents from textile/dye industries of sanganer, Jaipur(India): a case study. Ecotox. and Environ. Safe. 61: 105-113.

Mikhalovsky, S. V., Dmitriy I. Shvetz, Nina M. Open'ko, Vladimir V. Strelko and Waite, S. (1997 – 2000) Adsorption-Enhanced Phytoremediation Int. J. Phytoremidiat. 1: 304-308.

Mohana, S. Shrivastava, S. Divercha, J. and Madamwar D. 2007. Response Surface methodology for Optimization of medium for decolorization of textile dye direct Black 22 by a novel bacterial consortium. Bioresour. Technol. 99(3): 562-569.

Mojiri, A. Aziz, H. A. Zahed, M.A. Aziz, S.Q. Selamat M.R, B.2013 Phytoremediation of Heavy Metals from urban waste leachate by southern cattail (*Typha domingensis*). Int. J. Environ. Sci. 1: 63-70.

Mondal, S. 2008. Methods of Dye Removal from Dye House Effluent- An Overview. S. Mondal. Environ. Eng. Sci. 25(3): 383-396.

Moran, C. Hall, M.E. and Howell, R. 2009. Effect of sewage treatment on textile effluent. of phytoremediation. Int. J. Phytoremediat. 1: 125-138.

Mubeen, H. Naeem, I. and Taskeen, I. 2010. Phytoremediation of Cu (II) by *Calotropis procera* roots. Newyork Sci. J. 3:1-5.

Mugdha, A. and usha, M. 2011. Enzymatic treatment of waste water containing dyestuff using different delivery system. Sci. Revs. Chem. Commun. 2: 31-40.

Muthunarayanan, V., Santhiya, M., Swabna, V., Geetha, A. 2011. Phytoremediation of textile dyes by Water Hyacinth (*Eichhornia crassipes*) from aquas dye solutions. Int. J. Environ. Sci. 1: 1702-1708.

NIC National Informatics Center. 2006 Ministry of Communication and Information Technology Collection, Bhilwara-311001, Rajasthan, India.

Nigam, P.Mullah, G. MC. Banat, I.M. and Merchant, R. 2004. Decolorization of effluent form the textile industry by a microbial consortium. Biotechnol. Letter. 18: 11-120.

Noreen, H. Zia, M.A. Ali, S. and Hussain,T.2014. Optimization of bio-polishing of Polyester/cotton blended fabrics with cellulases prepared from *Aspergillus niger*. Indian J. Biotechnol. 13: 108-113.

Novotony, C. Dias, N. kaanen, A. Malachova, K. Vandrovcova, M. Itavaara, M. and Lima, N. 2006. Comparative use of bacterial algal and Protozoan tests to study toxicity of azo- and anthraquinone dyes. Chemosphere. 63: 1436-1444.

Patel, S.S. and Srivastava V.S.1999. Impact of Textile, Dyeing and printing industrial effluent on soil and ground water quality: a case study. Indian J. Environ. Prot. 19: 771-773.

Phillips, E. J. P. Lunda, E. R. and D. R. 1995. Remediation of uranium contaiminated soils with bicarbonate extraction and microbial U (VI) reduction. J. Ind. Microbiol. 14: 203-207.

Pourbabee, A. A. Malekzadeh, F. Sarbolouki, M. N. and Najafi F. 2006. Aerobic decolorization and detoxification of a disperse dye in textile effluent be a new isolate of *Bacillus* sp. Biotechnol. Bioeng. 93: 631-635.

Purohit, P. 2006. Biomonitorning and Phytoremediation of Radioactive Pollution with Special Reference to Rajasthan. Ph. D. Thesis. M. D. S. University, Ajmer, India

Ramachandran, P. Sundharam, R. Palaniyappan, J. and Pudukkadu, A. Munusamy. 2013. Potential process implicated in bioremediation of textile effluents: a review. Adv. Appl. Sci. Res. 4:131-145.

Rao. M.A. Scelza R. Scotti R. and Gianfreda, L. 2010. Role of enzymes in the remediation ofpolluted environments J. Soil Sci. Plant Nutr. 10: 333- 353.

Roane, T. M. Perpper and miller. 1996. Microbial remediation of metals. In: Bioremediation Principles and Application (Craford, I. Ronald & Cfawford, L. Don. Eds.) Cambridge University Press, Great Britain. pp. 312-340.

Romeh, A. A. 2014 Phytoremediation of cyanophos insecticide by *Plantgo major* L. in water. J. Enviorn. Health Sci. Eng. 12:38.

Salt, D.E. Prince, R. C. Baker, A.J.M. Raskin, I. Pickering, I.J. 1999. Zinc legend in the metal hyperaccumulator Thlaspi coerulesecens as determined using-ray absorption spectroscopy. Environ. Sci. Technol. 33: 713-717.

Sen, S. and Demirer, G. N. 2003. Anaerobic treatment of real textile waste water with a fluidized bed reactor. Water Res. J. 37: 1867-1878.

Serfor- Armah Y. Nyarko B. T.B. Osae E. K., Carboo D., Anim-Sampong S. and Seku F. 2004. Rhodophyta seaweed species as bioindicators for monitoring toxic element pollution in the marine ecosystem of Ghana. Water, Air Soil Pollut. J. 127: 234-253.

Sharma, K.C. Hussain and Ojha K.G.2001. Ground water quality of an industrial town Bhilwara, Rajasthan. J. Environ. Pollut. 8: 109-114.

Sharma, K.P. Sharma, K. Bhardwaj, S.M. Chaturvedi, R. K. and Subhasini 1999. Environment impact assessment of textile printing industries in sanganer Jaipur: A case study J. Indian Bot. Soc. 78: 71-85.

Sidi, S. and Tank, S. 2014. To study the pollution load reduction potential of *Eichhornia crasspus* (Water Hyacinth) in the kadodara khadi, Surat. Int.J. Sci. Res. Devl. 1:2468-2471.

Sukumaran, D. Anilkumar, A. Kumar, A. Dubey, A. K. thanga, S.G. 2012. Phytoremediation-the clean up technology for the future . Int. J. Phytoremediat. 1: 307-312.

Sultana, M.S. Islam, M.S. Sha, R. and Al-Mansur, M. 2009. Impact of the effluent of textile dyeing industries on the surface water quality inside D.N.D. Embankment, narayanganj. Bangladesh J. Sci. Ind. Res.1:137-151.

Suzuki, Y., Kelly, S. D., Kemner, K. M. and Benfield, J. M. 2002. Radionuclide contamination: Nanometre-size products of uranium bioreduction. Nature. 419: 134.

Textile Minstry, Government of India, Annual report. 2004-2005: 1, 2005: 1-17.

Trivedi, R. K. and Goel, P. K. 1986 Chemical and Biological Methods for Water Pollution Studies. Environmental Publication, Karad, India.

Van Der lelie, D. Schwitzguebel, J. P., Glass, D. J., Vangronsveld, J. and Baker, A. 2001. Assessing phytoremediation's progress in the United States and Europe Environ. Sci. Technol. 35: 446A-452A.

Varun, M., D'Souza, R., Pratas, J. and paul, M. S. 2012. Metal contamination of soils and plants associated with the glass industry in north central India: prospects of phytoremediation. Environ. Sci. Pollut. Res. 19: 269-281.

Vidali M. (2001). Bioremediation. An Overview. Pure Appl. Chem. 73(7) : 1163-1172.

Watharkar, D.A. Khandare, R.V. Kamble, A. A. Mulla, A.Y. Govindwar, S.P. Govindwar, J.P. Jadhav, 2012. Phytoremediation potential of *Petunia Grandiflora* , an ornamental

plant to degrade a disperse, disulfonated triphenylmethane textile dye Brilliant Blue J. Environ. Sci. Pollut. Res. 10:1007-1012.

Zyanda,T.2001.Phytoremediation.http://www.enviro-tools.or/factsheet/phytoremediation.pdf.

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